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Dr. Walter Menaker
69-09 108th Street
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Dear Dr. Menaker:

Thank you for your recent letter concerning my contribution to the CBS program on the Warren Report. I once leafed through a copy of Thompson's book, when I was in the San Francisco Airport bookshop, and I noted that Dr. Thompson did not have a very clear idea of what I had done. But that is not surprising, since Mr. Wyckoff gave a very abbreviated and highly simplified version of my observations, which he repeated independently.

I documented my observations and measurements in two rather long letters to CBS, totalling about 15,000 words. I believe it is typical of the intelligence of the people who write books of the sort Dr. Thompson produced, that they think someone who is experienced enough in the making of physical observations, that he could be a professor of physics at one of the leading institutions in the world, could overlook some blurs in some photographs, particularly when he appears to be the first one who had ever called attention to these blurs, in a substantive way. Of course, I, and Mr. Wyckoff as well, looked at every single photograph that was reproduced in the Warren Report, and not only made detailed measurements of the blurs, but in addition determined in what direction the camera was being traversed during that particular frame. What I did was to measure the length of each blur, which is of course proportional to the angular velocity of the optical axis of the camera system. By looking at the background in the photographs preceding and following that particular blurred photograph, I could tell which way the camera had moved during the blur. As a result of this, I could assign the length of a blur as, for example, plus 3 millimeters, or minus 1.5 millimeters, where the plus or minus signs indicate clockwise or counterclockwise rotation of the camera, as seen from a point above the operator. Naturally, from the point of view of the physicist, I was not interested in the angular velocity of the camera, but rather in the angular acceleration, since Newton's Second Law tells us that the angular acceleration of an object is proportional to the torques acting on it. (The most common version of Newton's Second Law is that the acceleration is proportional to the force, but this is for systems that move in a linear fashion, whereas we are dealing with a camera which is being moved in an angular sense). An angular acceleration is simply the difference in the angular velocities, divided by the time interval between the two measurements of angular velocity. Since the time interval between all successive frames is the same -- about 18.3

seconds, one can get numbers that are proportional to the angular accelerations, simply by subtracting the algebraic numbers that are proportional to the angular velocities. By making this subtraction of angular velocities, including the algebraic sign, I then came up with a table of numbers that was proportional to the angular acceleration of the camera, corresponding to a time midway between each pair of successive frames. I then plotted these angular acceleration values, which could be either plus or minus, as a function of the frame number. The startling thing was that there were three "trains of pulses", each lasting almost exactly one second, with a definite starting pulse, and a definite final pulse. One of these sets of pulses started at Frame 313, confirming the method, and the other two started at Frames whose numbers I can't remember, and since my original letters are at home, I won't bother with them. (Probably they are the frames mentioned by Mr. Wyckoff in his report on CBS television.) The conclusion I drew then, and the one with which Mr. Wyckoff agreed, was that each shot set the neuromuscular system of Mr. Zapruder into oscillation, and it took approximately one second for him to damp out the oscillations. As far as I could tell from the photographs that were shown in the CBS report, Mr. Wyckoff duplicated these trains of oscillatory pulses in his reenactment of the photography sequences. You will remember that there were photographs showing two or three photographers holding Bell and Howell movie cameras, showing that they reacted to the shock wave of a passing bullet, by going into a neuromuscular oscillation, with a recovery time of approximately one second.

I was not able to examine pictures earlier than the first one shown in the Warren Report, but Mr. Wyckoff did go back to the Archives in Washington, and made similar measurements for the Zapruder frames from 1 up to the one first shown in the Warren Report. He showed that although some of the frames did have appreciable blurs, the length of the blurs varied smoothly with frame number, and simply were a result of the fact that Mr. Zapruder was spraying his camera back and forth like a rank amateur photographer, rather than like the real pro he appeared to be when he settled down to take pictures, when Mr. Kennedy came into view. Incidentally, this observation shows clearly why one should not pay any attention to blurs, but only in the curve showing the difference in blur lengths from print to print. Mr. Wyckoff then, and correctly I believe, concluded that the oscillatory trains which are visible in the photographs reproduced in the Warren Report were really due to some rather distinctive phenomenon, and not due to the fact that Mr. Zapruder had the hiccups, as District Attorney Garrison commented in his appraisal of the work that Mr. Wyckoff and I did on the films! (In the whole sequence of photographs, the oscillatory pulse trains are concentrated into a narrow time region, including the known time range in which everyone agrees that at least two shots were fired. A physicist would say "the background was

essentially zero".)

I concluded then that three shots, and only three shots were fired, and I pinpointed the times, within a very small fraction of a second, for each shot. In addition to these three very obvious places at which shots were no doubt fired, there was another rather weak set of pulses, about half way between what I labeled as the second shot, and the very obvious third shot that killed the President. This set bothered me for a long time, but I finally came to what I believe is a proper explanation for this weak train. Although the FBI photo interpreters who testified before the Warren Commission, said that there was no way one could tell the accurate position or velocity of the car, when the background was blank (grass), I found two quite separate ways to do this, both of which gave the same value of the car's velocity, and both showed a very sharp change in velocity at just the time that the fourth weak train of oscillatory pulses took place. I puzzled over this for several days, and then I read that at about the time of the last shot, the Secret Service car just behind the President's car turned on its siren. Since no one was very clear about exact times in this extraordinary few seconds, it occurred to me that the siren probably came on just before Mr. Zapruder's weak oscillations started, and just before the driver suddenly slowed down. After all, the men in the Secret Service car had seen the President hit, and it was only natural that they would have pressed the panic button, by starting up the siren. Everyone who has ever driven a car is taught to slow down as soon as he hears a police or fire engine siren, so it is not difficult to imagine that the driver of the President's car immediately let his foot up on the accelerator pedal, when he heard a siren go off twenty-five feet from his car. Actually the hard thing to understand is why the driver of the President's car kept going at exactly a constant rate during at least one, and I believe two shots to the car which he was driving. The only thing that I can think of in this connection is that he was reacting like a circus horse, who goes trotting around a ring, at constant speed, as the acrobats jump up on his back and turn somersaults. I believe that anyone driving the President's car would have let his foot up from the accelerator when he heard a siren like this. So we note that the driver of the President's car actually slowed down abruptly, and did not speed up as he certainly should have done. (Many people have pointed out that if the driver had speeded up and turned rapidly from left to right, the President might have survived the first bullet to hit him, and the last one probably would have missed him.) We must have an explanation of this really extraordinary behavior on the part of the President's driver, which, so far as I can tell, I am the only person to have noticed. I believe that the siren clearly explains it, and of course it would have triggered Mr. Zapruder into oscillation, although probably not as strongly as he was triggered into oscillation by the obvious gun shots. All of these things tie together, and I believe that I did come up with a consistent picture of the whole sequence of events that led to the angular accelerations of Mr. Zapruder's camera, that I measured in a very straightforward way.

I have usually refrained from describing in such detail the measurements I made, although I have been asked by many people for material of this sort. The main reason that I asked CBS to contract with a research organization of the M and G type, for which Mr. Wyckoff works, was so that I would not have to spend most of my life writing letters of this sort -- the monkey would be on their back. You can of course send a copy of this letter to Dr. Thompson, but I fear it will do no good -- in his mind I am simply an idiot who could not see some blurs on some photographs that he noticed after I had called attention to the phenomenon, or if I did see them, I did not think they were worth noting.

I hope you will not ask me for copies of my two very long letters, which I consider to be personal correspondence with two friends.

I am pleased to see that we have some friends in common, including some high school classmates, whose names I had not thought of in years.

Very sincerely,

Luis W. Alvarez

LWA:am